Available online at www.sciencedirect.com
ScienceDirect
Journal of Forensic and Legal Medicine 14 (2007) 195–202
JOURNAL OF FORENSIC AND LEGAL MEDICINE
www.elsevier.com/jflm

Original communication

Forensic considerations of missed diagnoses in trauma deaths

B.R. Sharma *, Manisha Gupta, Sumedha Bangar, Virender Pal Singh

Department of Forensic Medicine and Toxicology, Government Medical College and Hospital, Chandigarh 160030, India

Received 18 October 2005; received in revised form 11 December 2005; accepted 13 February 2006
Available online 17 August 2006

Abstract

Injuries missed at initial diagnoses or operations have the potential to cause disastrous complications in trauma patients. Understanding the etiology of unrecognized injuries is essential in minimizing its occurrence. For this purpose, we scrutinized the treatment and the autopsy records of the trauma deaths from 2000 to 2004 to determine the frequency, body regions, severity and causes of injuries that escaped recognition during the initial assessment, primary, secondary and tertiary surveys by the clinical team in patients who died of trauma. We also examined the accuracy of the cause of death as recorded on death certificates. The frequency of unrecognized injuries was found to be 11% in all trauma deaths. Abdomen (40%) and head (29%) were the more common regions of the body where injuries were frequently missed. System related errors (68%) and patient related factors (32%) were responsible for the injury remaining unrecognized. It was concluded that the injuries may be missed at any stage of the management of patients with major trauma and repeated assessments both clinical and radiological are mandatory not only to diminish the problem but to avoid litigation as well.

Keywords: Unrecognized injuries; Missed injuries; Trauma; Trauma-care; Death certificate

1. Introduction

Trauma patients pose a complex clinical challenge, which predisposes to missing injuries and delaying treatment. Whereas life-threatening injuries must not be missed, a review of the literature indicates that not all injuries are identified during the initial assessment and resuscitation phase.[1] The advanced trauma life support course (ATLS) has established an internationally accepted approach to primary and secondary trauma survey, which if adhered to may minimize the chance of an injury remaining unrecognized. However, it has been argued that even this approach will not guarantee that all injuries will be discovered and a concept of tertiary trauma survey or standardized clinical reassessment within 24 h of admission has been proposed to further reduce the incidence of unrecognized injuries.[2]

Reported rates of unrecognized injuries in trauma patients vary from 2% to 50%.[3–6] An evaluation of early missed injuries has reported the incidence as 65%. According to this study of 206 patients, there were clinically important missed injuries in 30 patients (15%) with complications in 11 patients of whom 2 died. The study further reports 224 contributing errors, of which 123 (35%) were in clinical assessment, 83 (40%) in radiology, 4 (2%) technical errors and 14 (7%) only were patient related.[7]

According to another study of 123 missed injuries in 117 patients, the cause of missed injury consisted of incomplete initial assessment or investigation in 51 (41%) cases, incomplete surgical exploration in 43 (41%) cases, failure to explore the patient in 17 (14%) cases and patient related reasons in 12 (10%) cases.[8] In yet another series of 607 patients with abdominal trauma, only 12 (2%) have been reported as missed injuries.[9] Patients sustaining blunt trauma have been reported to have a higher rate of missed

* Corresponding author. Address: #1156-B, Sector-32 B, Chandigarh 160030, India.
E-mail addresses: drbrsharma@yahoo.com, drbrsharma@gmail.com (B.R. Sharma).

1353-1131/$ - see front matter © 2006 Elsevier Ltd and AFP. All rights reserved.
doi:10.1016/j.jcfm.2006.02.027

injuries[10] than patients sustaining penetrating injury,[11] and the unrecognized injuries have been reported to range in severity from trivial to fatal.[12]

To date only a handful of autopsy assessment of unrecognized injuries have been reported. Albrektsen and Thomsen[4] reported a 34% missed injury rate but included only clinically insignificant injuries (abbreviated injury score less than 4). Hodgson[13] reported an unrecognized injury rate of 47% whereas clinical studies have reported that the incidence of unrecognized injuries decreased from 2.4% to 1.5% overall and from 5.7% to 3.4% in trauma intensive care unit patients after trauma survey introduction.[14] These variations suggest that clinical reviews without autopsy evaluation do not estimate the true magnitude of unrecognized injuries. Furthermore it raises the skepticism about the accuracy of the cause of death reported in the death certificate by the treating physician/surgeon.

Death certificate information within epidemilogic database is used for such purposes as tracking the health of the population, designing health care promotion and injury prevention programs, as well as guiding the allocation of resources for clinical, research and other health related programs. Therefore, these data must be accurate. The cause of death assigned by a clinician on the basis of autopsy findings in combination with clinical data is likely to be the best estimation of the true cause of death. The purpose of this study was twofold. Firstly, based on a consecutive series of autopsies of the patients, who died of trauma, we attempted to determine the frequency, body region and severity of injuries missed by the clinical team as well as the factors contributing to the injury remaining unrecognized and secondly, we examined the accuracy of death certificate filed on these trauma deaths by comparing the cause of death as furnished by the attending physician and the autopsy surgeon.

2. Material and methodology

This retrospective study was conducted at the Department of Forensic Medicine and Toxicology, Govt. Medical College and Hospital Chandigarh – a Tertiary Care Center, catering to the health and medical needs of the city, having a population of over one million people and a referral center for the adjoining states. Trauma victims subjected to medicolegal autopsy during the years 2000–2004, whose detailed history and case records were available, were the subjects of study, autopsy being mandatory for all trauma deaths in this region. However, this being a retrospective study, the data may not be necessarily representative.

Detailed data were collected on each patient including demographic, injury and treatment information from the injury scene and during pre-hospital care, through the entire hospital stay until the patient's death. Each patient's injury severity score (ISS) (based on AIS-90) was calculated twice, first on the basis of injury descriptions from the clinical records, and radiology, operative and pathology reports. This data set made up the 'Group-I'. Next the autopsy reports of individual patients were reviewed and used to update the injury list. Any new injuries were entered and the severity of previous injuries was updated. The ISS was then recalculated and the data assigned to the 'Group-II'.

A missed injury was defined as one that escaped detection during resuscitative, radiological, operative and pathological investigations (primary and secondary trauma surveys and initial investigation in the resuscitation room and/or operation theatre) but was identified through autopsy. Unrecognized injuries/complications were identified manually by comparing the injury list of patients in Group-I with the more detailed injury list of the patients in Group-II. Clinically significant unrecognized injury/complication was defined as one that caused significant pain, complications, residual disability, and death or resulted in prolonged hospital stay.

Based on the survival period, the patient care was divided into five stages: Stage-I – from the scene of occurrence to arrival of the patient to the emergency department of the hospital (Pre-hospital), Stage-II – from initial assessment/resuscitation in the emergency department to shifting of the patient to operation theatre/intensive care unit (ICU), Stage-III – surgical intervention/intensive care management to secondary trauma survey, Stage-IV – secondary trauma survey to tertiary trauma survey and Stage-V – after the tertiary trauma survey. The unrecognized injuries were totalled for all patients who died at different stages.

Factors responsible for the injuries remaining unrecognized were defined and classified into two main categories: (1) Patient related factors included haemodynamic instability with systolic blood pressure <90 mm of mercury and altered consciousness following head injury, intoxication or drug abuse and intubation and paralysis. (2) System related factors included (a) Clinical examination errors viz., Misinterpretation of appropriate information obtained on assessment, low index of suspicion of injury, inadequate assessment of all ISS body regions, omission of appropriate investigations, inadequate significance assigned to minor signs and symptoms. (b) Technical errors viz., procedural errors in technique contributing to unrecognized injury, failure to perform surgical exploration, incomplete surgical exploration and (c) Radiological errors viz., inadequate views, failure to X-ray, finding missed by radiologist, X-ray result not noted by treating physician, findings missed on X-ray by treating physician etc.

3. Results

Over a 5-year period, 15,407 trauma patients reported to the emergency department (some of them brought by police, some by the relatives of injured and some by the people present at the scene of accident/crime) Of these trauma patients, 1413 (9%) sustained penetrating injuries, 10,163 (66%) had blunt injuries and 3831 (25%) had received burns. 1035 (7%) of these trauma patients had a fatal outcome (Table 1).

Of the 1035 deaths due to trauma, 193 (19%) died in Stage-I (pre-hospital) and 194 (19%) died in emergency department before they could be shifted to the ICU/Trauma ward. Vehicular accidents were the main cause of trauma 589 (57%) cases, followed by burns 369 (36%) and mechanical violence 64 (6%) cases (Table 2).

The vast majority of the patients died from either central nervous system trauma (56%) or from multiple organ failure (33%) with no specified cause. The age group 20–30 years constituted the majority of trauma victims (31%), followed by the age groups 30–40 (25%) and 10–20 years (20%) (Table 3).

The majority of deaths occurred in Stage-V 408 (39%), of which, 145 (36%) were due to burns. Deaths due to burns registered an increasing fatal outcome with 52 (14%) in Stage-III, 99 (27%) in Stage-IV and 145 (39%) in Stage-V. Trauma deaths following road traffic accidents predominantly occurred in Stage-I (160) and Stage-II (137). Significantly, the number of unrecognized injuries declined from 65% (61/94) in Stage-II to 35% (33/94) in Stage-III to Stage-V. Trauma patients dying in Stage-I, were either those who died at the scene of occurrence or those referred from peripheral hospitals after administering the first aid but died before reaching the emergency department. The rate of unrecognized injuries in these patients was almost 100%. Abdomen was the commonest region of the body where 25 (41%) injuries remained unrecognized in emergency department deaths and 12 (36%) among the in-hospital multi-trauma patients. Head region accounted for 16 (25%) in ED and 11 (33%) missed injuries among the in-hospital trauma deaths. Chest injuries registered a 50% drop of unrecognized injuries from emergency department to in-patient section. The overall rate of unrecognized injuries was found to be 11% (94/842) in trauma deaths (Table 4).

Factors responsible for the missed diagnoses were found to be Patient related in 30 (32%) and system related in 64 (68%) cases. Among the system related errors clinical assessment error was attributed to 30 (32%), Technical error to 17 (18%) and radiological error to 17 (18%) cases (Table 5).

In the present analysis, the median and range of ISS for Group-II (43 and 57) was significantly higher as compared to Group-I (30 and 33.5) for in-hospital deaths and emergency department deaths (Table 6).

Death certificate/summary, in majority of cases mentioned 'cardio-respiratory failure, as the cause of death assigned by the treating clinician.

Table 1
Annual distribution of trauma cases

Year	Trauma cases reporting to E.D.		Type of trauma						No. of Fatal cases	
			Penetrating		Blunt		Burns			
	No.	%	No.	%	No.	%	No.	%	No.	%
2000	2569	16.67	253	09.85	1669	64.79	647	25.19	195	07.59
2001	3012	19.55	181	06.01	2018	67.00	813	26.99	164	05.44
2002	2738	17.78	251	09.17	1941	70.81	546	19.94	193	07.05
2003	3473	22.54	349	10.04	2222	63.96	902	25.97	237	06.82
2004	3615	23.46	379	10.48	2313	63.98	923	25.53	246	06.81
Total	15,407	100.00	1413	09.17	10,163	65.96	3831	24.87	1035	06.72

Table 2
Survival period vis-à-vis manner of injury

Survival period	Manner of injury								Total	
	RTA		Burns		Violence		Others[c]			
	No.	%	No.	%	No.	%	No.	%	No.	%
Stage-I (S.D.[a]/B.D.[b])	160	27.17	25	06.78	05	07.81	03	23.08	193	18.65
Stage-II (1–6 h)	137	23.26	48	13.00	08	12.50	01	07.69	194	18.74
Stage-III (6–12 h)	22	03.74	52	14.09	07	10.94	03	23.08	84	08.12
Stage-IV (12–24 h)	44	07.47	99	26.83	11	17.19	02	15.39	156	15.07
Stage-V										
1–3 days	79	13.41	39	10.57	23	35.94	02	15.39	143	13.82
3 days–1week	94	15.96	96	26.02	10	15.63	01	07.69	201	19.42
>1 week	53	09.00	10	02.71	00	00.00	01	07.69	64	06.18
Total	589	56.90	369	35.65	64	06.18	13	01.26	1035	100.00

[a] Spot death.
[b] Brought dead.
[c] Fall, industrial accidents, etc.

Table 3
Causes of death vis-à-vis age group

Cause of death	Age group in years														Total	
	0–10		>10–20		>20–30		>30–40		>40–50		>50–60		>60			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Head injury	04	00.69	127	21.93	168	29.01	146	25.22	94	16.23	32	05.53	08	01.38	579	55.94
Multiple organ failure	01	00.30	72	21.37	110	32.64	84	24.93	51	15.13	15	04.45	04	01.19	337	32.56
Pelvic hemorrhage	01	03.03	04	12.12	12	36.36	10	30.30	03	09.09	03	09.09	00	00	33	03.19
Gastrointestinal bleed	00	00	01	05.26	07	36.84	04	21.05	03	15.79	03	15.79	01	05.26	19	01.84
Pulmonary embolism	00	00	00	00	04	44.44	01	11.11	02	22.22	01	11.11	01	11.11	09	00.87
Major blood vessel rupture	01	03.57	04	14.29	08	28.57	06	21.43	04	14.29	02	07.14	03	10.71	28	02.71
Spinal cord trauma	00	00	01	11.11	03	33.33	01	11.11	02	22.22	02	22.22	00	00	09	00.87
Disseminated sepsis	00	00	00	00	01	16.67	02	33.33	00	00	02	33.33	01	16.67	06	00.58
Acute myocardial infarction	00	00	00	00	03	20.00	01	06.67	04	26.67	04	26.67	03	20.00	15	01.45
Total	07	00.68	209	20.19	316	30.53	255	24.64	163	15.75	64	06.09	21	02.03	1035	100

Table 4
Nature of unrecognized injuries by body region

Body region	Unrecognized injuries						
	AIS[a]	Total cases ($n = 842$)		In-hospital deaths ($n = 664$)		ED[b] deaths ($n = 178$)	
		No.	%	No.	%	No.	%
Head							
• Subdural hematoma	4	11	11.70	4	12.12	7	11.48
• Epidural hematoma	5	3	3.19	1	3.03	1	1.64
• Cerebral laceration	4	8	8.51	2	6.06	6	9.84
• Diffuse axonal injury	5	5	5.32	4	12.12	2	3.28
Total	–	27	28.72	11	33.33	16	26.23
Chest							
• Cardiac injury	4–5	8	8.51	4	12.12	5	8.20
• Aortic laceration	4	5	5.32	1	3.03	4	6.56
• Subclavian artery laceration	4	1	1.06	0	0.00	1	1.64
• Flail chest	4	2	2.13	1	3.03	1	1.64
Total	–	16	17.02	6	18.18	11	18.03
Abdomen							
• Hepatic rupture	5	2	2.13	0	0.00	2	3.28
• Hepatic laceration (grade IV)	4	8	8.51	2	6.06	5	8.20
• Splenic rupture	5	6	6.38	1	3.03	5	8.20
• Splenic laceration (grade IV)	4	7	7.45	1	3.03	6	9.84
• Intestinal/mesenteric laceration	4	6	6.38	2	6.06	4	6.56
• Renal injury	4	7	7.45	4	12.12	3	4.92
• Inferior venacaval laceration	4	2	2.13	2	6.06	0	0.00
Total	–	38	40.43	13	39.39	25	40.98
Musculo-skeletal							
• Fracture spine	5	7	8.45	2	6.06	5	8.20
• Pelvic fracture	4	6	6.38	2	6.06	4	6.56
Total	–	13	13.83	4	12.12	9	14.75
Grand Total	–	94	11.16	33	35.11	61	64.89

[a] Abbreviated injury score.
[b] Emergency department.

4. Discussion

The problem of unrecognized injuries/complications in trauma patients is not so well documented in literature. Injuries are more commonly missed in blunt trauma patients as compared to those of penetrating trauma because of the need for simultaneously rapid assessment and resuscitation.[10] Such unrecognized injuries can have a negative impact on patient outcomes. Clinically significant missed injuries, especially abdominal or cervical spine injuries can lead to complications, high morbidity and even death. Autopsies are an important source of additional injury information in this population of patients and assist the clinical team in addressing this problem of unrecognized injuries/complications that are of clinical significance.

Table 5
Factors responsible for the injuries remaining unrecognized

Factors responsible	No. ($n = 94$)	%
(1) *Patient related factors*		
• Haemodynamic instability with systolic blood pressure <90 mm of mercury.	8	8.51
• Altered consciousness following head injury, intoxication or drug abuse and intubation and paralysis	22	23.40
(2) *System/medical errors*		
(a) Clinical examination errors		
• Misinterpretation of appropriate information obtained on assessment	5	5.32
• Low index of suspicion of injury	8	8.51
• Inadequate assessment of all ISS body regions	4	4.26
• Omission of appropriate investigations	4	4.26
• Inadequate significance assigned to minor signs and symptoms	9	9.57
(b) Technical errors		
• Procedural errors in technique contributing to unrecognized injury	3	3.19
• Failure to perform surgical exploration	8	8.51
• Incomplete surgical exploration	6	6.38
(c) Radiological errors		
• Inadequate views	9	9.57
• Failure to X-ray	3	3.19
• Finding missed by radiologist	2	2.13
• X-ray result not noted by treating physician	2	2.13
• Findings missed on X-ray by treating physician	1	1.06

Table 6
Comparison of the median and range of ISS for Group-I versus Group-II patients

Death subgroup	Group-I	Group-II	*p*-value
E.D. deaths	33.5 (10–75)	57 (19–75)	0.0001
In-hospital deaths	30 (5–75)	43 (14–75)	0.0001

We found that abdomen and the head were the regions with a higher frequency of unrecognized injuries followed by the chest. Our findings are in conformity with other studies reporting that the most frequently injured abdominal organs are spleen and/or liver in 25–60% cases, whereas the colon and stomach are reported damaged in 10% cases.[15] The ratio of blunt to penetrating trauma in cases of diaphragmatic injuries have been reported to range from 3:1 to 1:8.[16,17] The incidence of injury to bowel or mesentery after blunt trauma is estimated at 1%. The consequences of such a missed injury are reported to be significant in the form of higher morbidity and mortality.[18] According to a study of 202 patients, a delay in diagnosis of as little as 8 h from injury to definitive surgical therapy was associated with increased morbidity and mortality that was directly attributable to 'missed' intestinal injury.[19] According to another study, mortality and morbidity in patients with late presentation of diaphragmatic hernia is different than in those with acute trauma. In patients with acute diaphragmatic injury or rupture, irreversible shock and head injury are most often cited as causes of intra-operative or early post-operative deaths, whereas sepsis and multi-system organ failure predominate as late causes of death.[20] Because of the severity of blunt trauma required to rupture the diaphragm, associated injuries reported are head injury 25–55%, fractures of pelvis 15–55%, fractures of long bones 45–85% along with injuries to abdominal organs.[21,22]

The significantly high number of system related errors being responsible for unrecognized injuries/ complications might be attributed to infrastructure and the decision of the trauma team members for conducting various investigations. A study reporting occult pneumothoraces after blunt trauma chest[23] reveals failure to diagnose anterior pneumothorax by supine chest X-rays in four cases. It advocates the use of spiral computerized tomography scans of the chest in severely injured trauma patients. It has been contested that conventional radiograph units used routinely in the ICUs often fail to identify suspected intra-thoracic/abdominal injuries because of the patient and the equipment related variables.[24,25] Thoracic CT has been shown to improve the visualization of a variety of intra-thoracic abnormalities in critically ill patients.[26] Mirvis et al.,[27] reported that thoracic computed tomography (TCT) provides significantly more information in 70% of the CT studies compared with the corresponding radiographs in critically ill patients.

In the early 1980s, computed tomography in blunt trauma victims was used to estimate the extent of intracranial injuries. During the past two decades, CT has been increasingly integrated into trauma care. Indications for CT have been extended to the initial diagnosis of abdominal and retroperitoneal injuries and facial and spinal fractures. Since the early 1990s, the efficiency of emergency thoracic computed tomography has been investigated and discussed controversially in several publications.[28–33] Compared with CT, the sensitivity of conventional chest radiographs (CXR) has been reported to be only 42% for the detection of hemo/pneumothorax, 40% for diagnosing pulmonary contusion and 17% in the detection of atelectasis.[28] Though the use of routine emergency CT scan of the chest has been termed as diagnostic excess,[29] comparatively recent studies have reported that TCT was significantly more effective than radiographs and the additional information resulted in a change of therapy in 41% of patients.[32]

The introduction of newer and more accurate diagnostic modalities during the past three decades has not only greatly improved our ability to detect and treat multi trauma patients but also increased the expectations of the community.[34] However, hospitalization for observation is still the standard of practice for patients who have sustained blunt trauma head, thorax or abdomen despite having undergone diagnostic studies that may exclude the presence of injury to an internal organ. The perception that there is an important rate of false negative results associated with all standard diagnostic tests – physical examination, diagnostic peritoneal lavage,

Thoracic and abdominal computed tomography, and ultrasonography – has resulted in hospitalization for observation becoming the standard of medical practice. It is also widely held that even if no significant injury is discovered when a patient is first evaluated, in-hospital observation is the best means to identify any missed injury. In our study population, though the majority of deaths occurred in Stage-V but the incidence of unrecognized injuries registered a steep decline from 65% in emergency department deaths, to 35% among the in-hospital deaths, thus confirming the significance of repeated trauma surveys and hospitalization.

Analysis of the primary contributing factors for the missed diagnoses in our study revealed that over half of them were attributable to potentially avoidable factors. Notably, clinical examination error/inadequate clinical assessment was by far the most frequent contributing factor. Other studies have also attributed the majority of missed injuries to clinical error in patient assessment.[4,7,35] Of the technical errors failure to explore surgically was a common problem. Among the radiological errors, failure to take adequate view and misinterpretation were the dominant error in diagnostic workup, again reflecting conformity of our findings with those of other studies.[4,7,36] Several suggestions and actions, including regular reviews of the patient deaths with autopsy results, aggressive outreach education programs, the addition of tertiary trauma survey and enhanced working relationship among the trauma management team members are necessary to bring about any reduction in the rate of unrecognized injuries.[37]

Studies have reported abbreviated injury scale and its use in a forensic setting.[38,39] In our analysis, the significantly higher ISS in Group-II for both emergency department and in-hospital deaths indicated that the autopsy report contained either additional injuries or more detailed injury severity description than was presented in the clinical chart. This finding confirms that the information contained in the death certificate completed by the treating physician, may suffer from major inaccuracies. Accordingly, any health policies, prevention programs or resource allocation based on such information must be regarded as suspect because accurate death information is a basic requirement for the appropriate planning of health care policies. Unfortunately, the autopsy rate in many countries has been reported to be declining during the past three decades.[40,41] This decline has been attributed to lack of time, lack of interest and a perception of a differing diagnosis after death as a physician failure. This development needs to be reviewed in the interest of the trauma-care system development.

Documentation of trauma patients also seems to be one of the neglected areas.[42] Although, no specific guidelines are found in literature, regarding the documentation of evidence and the area seems to be left over to the trauma surgeon. Some areas of potential forensic deficiency could be identified as:

- Illegibility of hurriedly written notes in emergency.
- Non-mention of restraint devices and/or helmets (if applicable) being used or not in cases of motor vehicle accidents.
- Absence of comments about the modes of transport of the trauma victims from the scene of occurrence.
- Pre-hospital trauma-care teams frequently administer treatment and various forms of stabilization but then the general statement as to the patient's appearance and condition to discern if during this treatment there was improvement or deterioration is missing.
- Mechanism of injury that has become an extremely important factor in several aspects such as heightening the index of suspicion for occult injuries, designing regional patient triage protocol so that the patients with potential serious injuries are directed to trauma centers, and to assist in accident, crime scene, and medical examiner/autopsy surgeon investigation is not properly documented on many occasions.

Furthermore, objective descriptive terminology is extremely important in forensic cases. Examples of potential problems encountered in this area include references to gunshot wounds as "entrance or exit", patients with an altered mental status, possible head injury and smelling of alcohol, being labeled as "drunk" and patients whose complaints may be suspect for secondary gain being written up as "malingerers or gomers". On many occasions, physician's early subjective statements have been proved to be incorrect during subsequent investigation and/or court testimony, thereby diminishing physician's credibility.

There is an indiscriminate practice among the attending clinicians to give the immediate and direct cause of death as Cardio-respiratory arrest, which does not seem to be justified in the course of law as well as in medical perspective. Cardio-respiratory arrest is in fact a terminal event in human life and means stoppage of heart and lung function. Originally derived from the British procedure, the World Health Organization (WHO) recommends the following cause of death certification system[43]:

- The medical cause of death is divided into two parts, the first (Part I) being the condition which led directly to the death (This does not mean the mode of dying, such as heart failure, asphyxia, asthma, etc. it means the disease, injury, or complication which caused death) and the second (Part II) being other conditions, not related to Part I but which also contributed to the death.
- Part I is further divided into three subsections a, b and c, which are causally related to one another, in that 'a' is due to 'b' which in turn is due to 'c'. It should be clearly understood that it is the last letter of Part I, which is the primary pathological cause of death and the one, which is usually used for statistical purposes in compiling national and international mortality statistics. So it is

important to ensure that this lowest entry of Part I is the underlying pathological disease and not just a mode of death.
- Part II is most often legitimately used in old patients, where multiple pathology may be present and it is hard to decide which were the main causes of death. Apart from the aged, there can be deaths in which both sections of the certificate can rightly be used. For example, a person who has a myocardial infarct may already be suffering from cardiomegaly due to long-standing rheumatic valvular disease; it may be logical to suppose that such a heart would fail more readily because of the double pathological lesion. As the two conditions have no etiological connection, the infarct should be written in Part I and the rheumatic endocarditis in Part II.

The WHO classifies all diseases to be used both in clinical diagnosis and on death certificates in International Classification of Diseases (ICD). Each of the thousands of conditions is given a four digit ICD number which can be used for data recording and retrieval, used all over the world. In addition to these disease names, there is also the 'E-code', which has medicolegal relevance as it gives a number for all possible unnatural deaths.

5. Conclusions

- Major trauma presents major diagnostic and therapeutic problems. Any delay in providing the necessary treatment may lead to increased morbidity and mortality, prolonged length of hospital stay and increased cost.
- Unrecognized injuries/complications adversely affect not only patient outcome but also damage physician/institutional credibility by inviting litigation.
- The primary and secondary surveys were designed to identify all of a patient's injuries and prioritize their management. Implementation of tertiary trauma survey has also been recommended. However, unrecognized/missed injuries are still prevalent in severely injured and multi-system trauma patients and repeated assessments both clinical and radiological seem the only strategy to diminish the problem.
- Technological advances, on one hand, provide for better management and outcome, while on the other, increase the expectations of common man that may lead to increased litigation for alleged negligence.
- The information contained in the death certificates can be misleading and the health care planners utilizing this data may draw inaccurate conclusions regarding causes of death, which may have an impact on trauma-care system development.
- Retrospective clinical reviews without autopsy evaluation do not estimate the true magnitude of missed diagnoses and demand for a reviewed approach.

References

1. Enderson BL, Maull KI. Missed injuries: The trauma surgeon's nemesis. *Surg Clin North Am* 1991;**71**:399–418.
2. Enderson BL, Reath DB, Meadors J, Dallas W, DeBoo JM, Maull KI. The tertiary trauma survey: a prospective study of missed injuries. *J Trauma* 1990;**30**:666–70.
3. Juhl M, Mdler-Madsen B, Jensen J. Missed injuries in an orthopaedic department. *Injury* 1990;**21**:110–2.
4. Albrektsen SB, Thomsen JL. Detection of injuries in traumatic deaths; the significance of medicolegal autopsy. *Forensic Sci Int* 1989;**42**: 135–43.
5. Frawley PA. Missed injuries in multiply traumatized. *Aust NZ J Surg* 1993;**63**:935–9.
6. Hirshberg A, Wall MJ, Ramchandani MK, Mattox KL. Reoperation for bleeding in trauma. *Arch Surg* 1993;**128**:1163–7.
7. Janjua KJ, Sugrue M, Deane SA. Prospective evaluation of early missed injuries and the role of tertiary trauma survey. *J Trauma* 1998;**44**:1000–7.
8. Hirshberg A, Wall MJ, Allen MK, Matton KL. Causes and patterns of missed injuries in trauma. *Am J Surg* 1994;**168**:299–303.
9. Sung CK, Kim KH. Missed injuries in abdominal trauma. *J Trauma* 1996;**41**:276–8.
10. Born CT, Ross SE, Iannacone WM, Schwab CW, deLong WG. Delayed identification of skeletal injury in multisystem trauma: the 'missed' fracture. *J Trauma* 1989;**29**:1643–6.
11. Scalea TM, Phillips TF, Goldstein AS, et al. Injuries missed in operation: nemesis of the trauma surgeon. *J Trauma* 1988;**28**:962–6.
12. Hamdan TA. Missed injuries in casualties from the Iraqi-Iran war: a study of 35 cases. *Injury* 1987;**18**:15–7.
13. Hodgson NF, Stewart TC, Girotti MJ. Autopsies and death certification in deaths due to blunt trauma: What are we missing? *J Crit Care* 2000;**43**(2):130–6.
14. Biffi WL, Harrington DT, Cioffi WG. Implementation of a tertiary trauma survey decreases missed injuries. *J Trauma* 2003;**54**(1): 38–44.
15. McElwee TB, Myers RT, Penell TC. Diaphragmatic rupture from blunt trauma. *Am J Surg* 1984;**50**:143.
16. Aronoff RJ, Reynolds J, Thal E. Evaluation of diaphragmatic injuries. *Am J Surg* 1982;**144**:671.
17. Beauchamp G, Khalfallah A, Girand R. Blunt diaphragm rupture. *Am J Surg* 1984;**148**:292.
18. Wisner DH, Yong C, Blaisdell FW. Blunt intestinal injury. *Arch Surg* 1990;**125**:1319–23.
19. Fakhry SM, Brownstein M, Watts DD, et al. Relatively short diagnostic delays (<8 hours) produce morbidity and mortality in blunt small bowel injury: an analysis of time to operative intervention in 198 patients from a multicenter experience. *J Trauma* 2000;**48**(3): 408–13.
20. Reber JU, Schmied B, Seiler CA, Baer HU, Patel AG, Bachler MW. Missed diaphragmatic injuries and their long term sequelae. *J Trauma – Injury Infect Crit care* 1998;**44**(1):183–8.
21. Guth AA, Pachter HL, Kim U. Pitfalls in the diagnosis of blunt diaphragmatic injury. *Am J surg* 1995;**170**:5.
22. Meyers BF, McCabe CJ. Traumatic diaphragmatic hernia. *Ann Surg* 1993;**218**:783.
23. Collins JA, Samra GS. Failure of chest X-rays to diagnose pneumothoraces after blunt trauma. *Anaesthesia* 1998;**53**:74–8.
24. Mirvis SE, Rodrigues A, Whitley NO, et al. CT evaluation of thoracic infections after major trauma. *AJR* 1985;**144**:1183–7.
25. Ovenfors C, Hedgecock MW. Intensive care unit radiology: problems of interpretation. *Radiol Clin North Am* 1978;**16**:407–39.
26. Snow N, Bergin KT, Horrigan TP. Thoracic CT scanning in critically ill patients: information obtained frequently alters management. *Chest* 1990;**97**:1467–70.
27. Mirvis SE, Tobin KE, Kostrubiak I, et al. Thoracic CT in detecting occult disease in critically ill patients. *AJR* 1987;**148**:685–9.

28. McGonigal MD, Schwab WC, Kauder DR, et al. Supplemental emergent chest computed tomography in the management of blunt torso trauma. *J Trauma* 1990;**30**:1431–4.
29. Poole VG, Morgan DB, Cranston BE, et al. Computed tomography in the management of blunt thoracic trauma. *J Trauma* 1993;**35**: 296–300.
30. Smejkal R, O'Malley KF, David E. Routine initial computed tomography of the chest in blunt torso trauma. *Chest* 1991;**100**:667–9.
31. Toombs BD, sandler CM, Lester RG. Computed tomography of chest trauma. *Radiology* 1981;**140**:733–8.
32. Trupka A, Waydhas C, Hallfeldt KK, et al. Value of thoracic computed tomography in the first assessment of severely injured patients with blunt chest trauma: results of a prospective study. *J Trauma* 1997;**43**:405–11.
33. Navarrete Navarro P, Vazques G, Bosch JM, et al. Computed tomography versus clinical and multidisciplinary procedures for early evaluation of severe abdomen and chest trauma – a cost analysis approach. *Intensive Care Med* 1996;**22**:208–12.
34. Livingston DH, Lavery RF, Passannante MR, et al. Admission or observation is not necessary after a negative abdominal computed tomographic scan in patients with suspected blunt abdominal trauma: results of a prospective, multi-institutional trial. *J Trauma – Injury Infect Crit Care* 1998;**44**(2):273–82.
35. Kremli MK. Missed musculoskeletal injuries in a university hospital in Riyadh: types of missed injuries and responsible factors. *Injury* 1996;**27**:503–6.
36. Reid DC, Henderson R, Saboe L, Miller JD. Etiology and clinical course of missed spine fractures. *J Trauma* 1987;**27**: 980–6.
37. Sharma BR, Gupta M, Harish D, Singh VP. Missed diagnoses in trauma patients vis-à-vis significance of autopsy. *Injury* 2005;**36**(8): 976–83.
38. Wyatt JP, Beard D, Busuttil A. Quantifying injury and predicting outcome after trauma. *Forensic Science International* 1998;**95**:57–66.
39. Wyatt JP, Beard D, Busuttil A. Use of the abbreviated injury scale to identify preventable deaths. *Am J Forensic Med Pathol* 1999;**20**:102.
40. Goldman L, Sayson R, Robbins S. The value of the autopsy in three medical eras. *N Engl J Med* 1983;**308**:1000–5.
41. Pollock DA, O'Neil JM, Parrish RG. Temporal and geographic trends in the autopsy frequency of blunt and penetrating trauma deaths in the United States. *JAMA* 1993;**269**:1525–31.
42. Sharma BR. Clinical forensic medicine – management of crime victims from trauma to trial. *J Clin Forensic Med* 2003;**10**(4): 267–73.
43. Knight B. *Forensic pathology*. 2nd ed. Arnold Publications; 1996. p. 54–55.